J Transp Secur (2014) 7:1–16
DOI 10.1007/s12198-013-0125-z

Mass-casualty attacks on public transportation

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Received: 4 July 2013 / Accepted: 8 July 2013 / Published online: 20 July 2013

Abstract The 21st century has provided many examples of the devastating effects attacks can have when public transportation has been targeted or used as weapons. Four hundred and seventy seven mass-casualty attacks (≥10 fatally injured and/or ≥100 non-fatally injured) against public transportation and terminal buildings during the years 1970–2009 were studied with data from the Global Terrorism Database in addition to open media sources, scientific journals, and books. Asia was the most frequently targeted region, followed by the Middle East & North African region and Sub-Saharan Africa. Airplanes were the most frequently attacked mode of transport during the 1970s, but were surpassed by buses in the mid-80s. There was also an alarming increase in attacks against terminal buildings during 2000–2009. The two most common types of attacks were bombings and armed assault. Complex tactical approaches so as to achieve as much carnage as possible were apparent—e.g., maximizing the number of exposed people, enhancing weapon effects, approaching victims one-by-one, combining several attack types, and targeting rescue personnel. These approaches were more predominant during the last two decades and attacks against rescue personnel were exclusive to the 21st century. The average number of injured increased considerably, despite a quite stable incidence rate since the 1980s. High numbers of non-fatally injured people were connected to attacks on terminal buildings, multiple targets and complex tactical approaches. These incidents, with more and more non-fatally injured, challenge our societal response structures and thus require more research.

Keywords Antagonism · Mass transportation · Terrorism · Transit · Violence

Introduction

Public transportation is inherently vulnerable to attacks due to its openness and availability. The various modes of transport often pass specified locations at certain intervals, have a wide geographical coverage, offer the possibility of anonymity, have

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many escape routes, and are dependent on their availability to large numbers of people—properties which can make them rewarding targets for people with malicious intent (Jenkins 2001; Wilson et al. 2007). Public transportation has both been the means and goals for attacks, as seen during the attacks on 9/11 in the USA, which changed the way we perceive modern society's vulnerability and risk. Other high-profile mass-casualty attacks (MCAs) on public transportation include Tokyo 1995 (Tokuda et al. 2006), Madrid 2004 (Bolling et al. 2007), London 2005 (Lockey et al. 2005), Mumbai 2006 (Rai and Sengupta 2006), and Moscow 2009 (The Economist 2009) and 2010 (BBC 2010). Moreover, there are similar threats to the surrounding infrastructure such as stations and terminals, as seen in the Minsk metro (The Economist 2011) and Moscow airport, both in 2011 (BBC 2011).

Public transportation has become an obvious target for attacks throughout the world. Terrorist acts against public transportation, as a type of antagonistic mass-violence, have intensified during the last four decades (Jenkins and Butterworth 2010), with urban public transport systems increasingly becoming the target of such hostile acts (Loukaitou-Sideris et al. 2006). While such systems have been around for about 150 years, terrorist attacks against them are a relatively recent phenomenon, growing in frequency since about 1970 and accelerating since the 1990s (Jenkins and Butterworth 2010). Public transportation, such as trains, not only symbolizes the functioning of economic and daily life due to its characteristics, meaning they can be valuable targets for psychological or propagandistic reasons, but attacks on these systems can also produce a large number of casualties (Wilson et al. 2007). Research has shown that these attacks are usually and increasingly designed to kill (Jenkins and Butterworth 2010) and indeed succeed in causing a higher percentage of fatalities than terrorist attacks in general (Jenkins 2004). Thus, contemporary society requires effective, safe public transportation, as well as preparedness of relevant societal structures with resources and expertise to provide citizens with help if an attack occurs.

High profile cases, such as 9/11, may lead one to assume that contemporary antagonism is increasingly technical and dependent on advanced weapons, but the vast majority of attacks involve explosives or firearms (LaFree et al. 2010). Thus, terrorist attacks increasingly result in explosion injuries, at times complicated by detonations in confined spaces (Leibovici et al. 1996). Moreover, secondary threats against responding professionals increase the risk of causing more death and destruction and impeding medical treatment (Stein and Hirshberg 1999; Frykberg 2002), which in turn requires special techniques and tactics from the police and medical personnel (Hodgetts and Mackway-Jones 2004). Meanwhile, attacks on public transportation can amount to additional difficulties, e.g., regarding medical evacuation in some locations (Björnstig and Forsberg 2010; Levinson and Granot 2002), in addition to the special injury spectrum due to antagonistic violence (Shapira and Cole 2006). By mapping previous incidents, this study is an important first step in reducing the consequences of an attack, with respect to mortality and injuries.

Aim

This study investigates international trends of mass-casualty attacks on public transportation and associated terminal buildings, during the years 1970–2009, focusing on

temporal and geographical patterns, attack type, and the number of fatally and non-fatally injured.

Methods and materials

Conducting a study combining research relating to mass casualty incidents, antagonism, and public transport entails challenges that require careful consideration regarding definitions, sources of data, and selection criteria.

Definitions and limitations

The study entails "mass-casualty attacks", which are not just confined to terrorism but a wider sphere of hostile acts, including large-scale violence in the form of mass murder and attacks based on ethnicity, oppression by state powers, and incidents in which the perpetrator or cause was disputed. Thus, the reason for the violence is not in focus but rather its effects, in terms of human suffering and mortality. The motive for this broad approach was to include several large-scale attacks that would otherwise have been excluded due to some technical uncertainty or deliberate concealment. To be considered an MCA, the arbitrary cut-off point chosen for this study was 10 dead and/or 100 non-fatally injured people. This number was chosen since it has been used as part of the labeling of an incident as a disaster by the Center for Research on the Epidemiology of Disasters (CRED)(2009). Of course, what constitutes a disaster is not in reality determined by transgressing a specific number of casualties, but rather when the need for aid is disproportionately high to the available resources and management capacity (Hodgetts and Mackway-Jones 2004).

"Public transportation" implies a means of transport where passengers are not traveling in their own vehicles. It is pre-organized, with regular transportation available to the public. This includes local, regional, national, and international modes of transportation such as trains, buses, trams, trolleys, subways, ferries, and airplanes, as well as associated terminals and stations. Examples of services that were excluded are chartered buses, private car-sharing, and taxis.

"Multiple targets" has been chosen as a label for attacks against distinguishable incident sites during the same day, no matter if these sites were connected to similar and different transport modes—i.e., multi-site attacks against public transportation as part of a coordinated assault. This implies, e.g., that the attack in Madrid 2004 was counted as one incident (not four based on different locations, nor ten based on the number of detonated bombs) in the "multiple target" category. The need for a special category for such attacks is clarified by way of comparison to the attacks in London 2005 where both subway trains and a bus were targeted simultaneously. Coordinated multi-site attacks like those perpetrated in Madrid and London share several characteristics which imply that they will likely require a different type and scope of management than single attacks.

Lastly, "non-fatal injuries" are restricted to physical injuries, thus possibly excluding cases that resulted in psychological trauma among many people. Terrorism as a method partly aims to create a state of fear in a broader population than those directly involved (Wilkinson 2011); consequently, it's designed to also inflict psychological injury or suffering, though this is an aspect that will not be examined in this study.

Materials

The collected data was based partly on open-source data from the Global Terrorism Database (GTD) and partly on other open media sources, scientific journals, and books.

The Global Terrorism Database (GTD)

The GTD is maintained by The National Consortium for the Study of Terrorism and Responses to Terrorism (START) at the University of Maryland and includes cases of terrorism, e.g., against public transport, aviation and maritime targets, from more than 104,000 terrorist incidents recorded between 1970 and 2011 (The National Consortium for the Study of Terrorism and Responses to Terrorism 2012).

To be included in the GTD, the incident must: (a) be intentional; (b) entail some violence or threat of violence; and (c) be perpetrated by a sub-state actor. Additionally, two out of three supplementary criteria must be filled: (1) the act must be aimed at attaining a political, economic, religious, or social goal; (2) there must be evidence of an intention to coerce, intimidate, or convey some other message to a larger audience than the immediate victims; (3) the action must be outside the context of legitimate warfare activities (The National Consortium for the Study of Terrorism and Responses to Terrorism 2011).

Complimentary data sources

The scope of this study goes beyond what the GTD encompasses due to the database's inherent focus on terrorism, its inclusion criteria, and its total absence of data (due to loss) from the year 1993. Additional cases were sought from scientific journals (e.g., Journal of Trauma, Prehospital and Disaster Medicine, Studies in Conflict and Terrorism), reports (e.g., from Mineta Transportation Institute, National Counterterrorism Center, CIA), books (e.g., Semmens 1994; DeRouen and Heo 2007; Rubin and Rubin 2008), news channels (e.g., Al Jazeera, BBC, CNN) and (> 25) newspapers (e.g., China Daily, Los Angeles Times, The Tribune-India), as well as websites (e.g., from the organizations Human Rights Watch, UNHCR, and Action on Armed Violence). Since media reports may contain inaccuracies, lies, or conflicting information, thorough checks of each case, with at least three independent sources, were deemed necessary in order to be included in the study.

Selection criteria

The inclusion criteria were that the event 1) occurred between the years 1970–2009, 2) occurred on or next to a public transportation vehicle or station, 3) targeted a mainly civilian population, and 4) resulted in at least 10 people fatally injured and/or 100 or more people non-fatally injured. Thus, if an event met all these criteria, it was included, whether perpetrated by state-, non-state, or unknown actors, or caused "by mistake."

Out of the included cases, 329 were found in the GTD, 96 were found in other sources, and 52 additional cases were backtracked to the GTD, where they had been categorized or counted in a way that made them previously excluded.

Presentation of data

Data regarding geographic distribution is divided into 7 regions, where the GTDs original 13 regions (LaFree and Dugan 2007) were compounded into: Asia (South Asia, East Asia, Southeast Asia), Europe (Western Europe, Eastern Europe), Latin America (South America, Central America & Caribbean), Middle East & North Africa, North America, Russia & the Newly Independent States (NIS) (including Central Asia), and Sub-Saharan Africa. No MCA on public transportation occurred in the Australasia & Oceania region.

Results

Distribution of attacks in the world

There were 477 MCAs on public transportation during the years 1970–2009. Most of the attacks occurred in Asia (*N*=236; 50 %), with more than double the attacks of the second worst hit region, the Middle East & North Africa (*N*=104; 22 %), and almost four times as many as the third most attacked region, Sub-Saharan Africa (*N*=63; 13 %). The remaining, roughly 15 % of attacks, were shared among Latin America (*N*=30; 6 %), Russia & the NIS (*N*=21; 4 %), Europe (*N*=19; 4 %), and North America (*N*=4; 1 %) (Fig. 1). The most affected countries were India (*N*=77; 16 %), Sri Lanka (*N*=68; 14 %), and Algeria (*N*=32; 7 %), together accounting for more than a third of all incidents.

Transport mode targeted

During the first decade, 1970–1979, airplanes were the type of transport where MCAs on public transportation were most common (*N*=21). Attacks against airplanes were

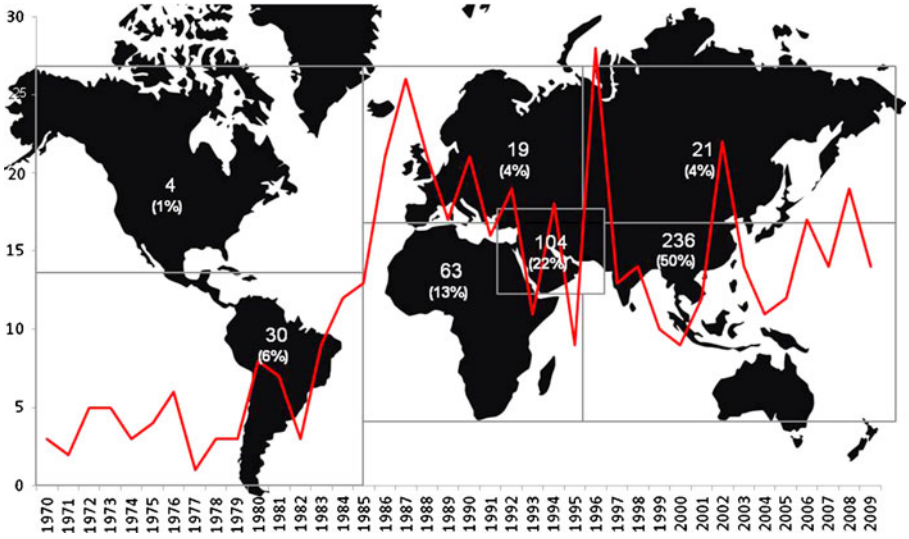

Fig. 1 Regional distribution of MCAs on public transportation and total incidence, 1970–2009

even more frequent (*N*=25) during the 1980s, but by then attacks against trains (*N*=28) and buses (*N*=65) had also become increasingly common. From 1985 onwards, road-bound modes of public transportation were the worst hit practically every year, at times suffering two to three times as many attacks as the other modes of transport. Attacks against ferries have been quite rare, with almost all of the incidents (*N*=20; 87 %) clustered between the years 1984–1996. Attacks against terminal buildings and multiple-target attacks occurred infrequently over the years, but became more common after the year 2000. Out of the total number of attacks against stations, harbors, and airports (*N*=46), more than half (*N*=27; 59 %) occurred during the last decade (Fig. 2).

Seen in total during the four decades, MCAs on public transportation were most common (*N*=251; 53 %) in connection to road-bound transport, accounting for over half of all incidents. The road-bound sector was the primary antagonistic target in the Middle East & North Africa (*N*=75; 72 %) as well as Latin America (*N*=20; 67 %), Asia (*N*=123; 52 %), and Sub-Saharan Africa (*N*=29; 46 %). After road, rail (*N*=78; 16 %) and air (*N*=56; 12 %) were the most frequently targeted transport types. Most of the attacks against the rail-bound sector occurred in Asia (*N*=45; 58 %) and Sub-Saharan Africa (*N*=14; 18 %), but trains and subways were disproportionately popular targets for attacks in the Russia & NIS region (*N*=8; 38 %), accounting for more than a third of the attacks there. Airplanes were mostly targeted in Asia (*N*=20; 36 %), and were the most common sector for MCAs on public transportation in Europe (*N*=8; 42 %). Most of the attacks against water-borne transport (*N*=14; 61 %) and multiple targets (*N*=11; 48 %) took place in Asia. Terminals were almost exclusively targeted in Asia (*N*=23; 50 %) and the Middle East & North Africa (*N*=16; 35 %), and most commonly in connection with buses (*N*=20; 43 %).

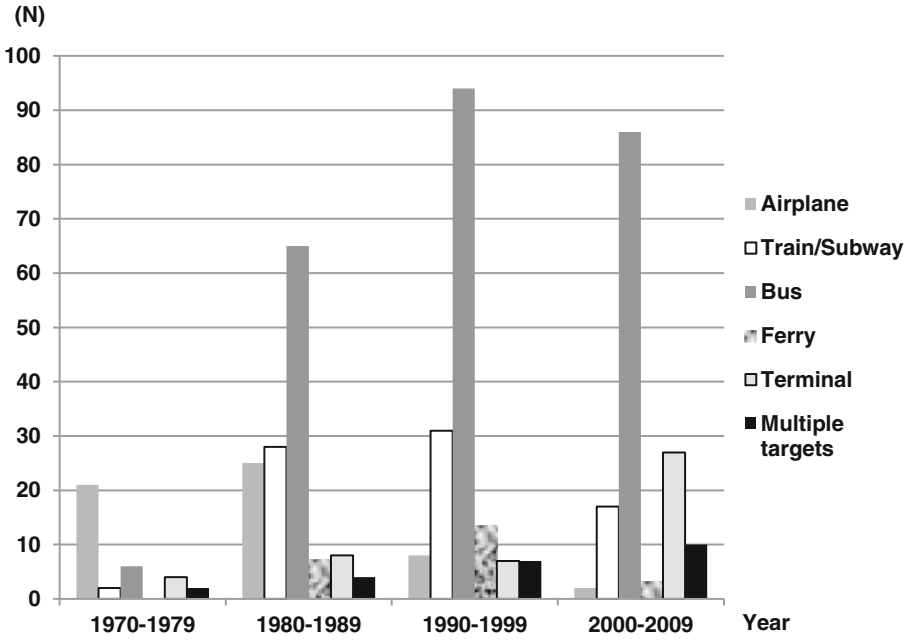

Fig. 2 Distribution of attacks by target, 1970–2009

Type of attack

Bombings accounted for more than half of the attacks (*N*=264; 55 %) and the second most common type of attack was armed assault (*N*=158; 33 %). These two attack types were used in nearly 9 out of 10 of cases. Most of the bombings (*N*=122; 46 %) and armed assaults (*N*=113; 72 %) were directed against the road-bound sector and took place in Asia. Hijacking and hostage taking, the third most commonly used attack type (*N*=24), accounted for about 5 % of all attacks and were also most commonly used in Asia (*N*=11; 46 %). Sabotage (*N*=9; 2 %), solely used against trains through removal of critical equipment or track, was exclusive to Asia (*N*=7) and Sub-Saharan Africa (*N*=2). Arson (*N*=8; 2 %) as primary attack type was also mainly used in Asia (*N*=3) and Sub-Saharan Africa (*N*=2) and mostly against the road- (*N*=3) and rail-bound (*N*=2) sectors. In the few cases where the type of attack was labeled other/unknown (*N*=14; 3 %), this was either because the incident did not fit into the other categories, like intentional crashes by pilots (*N*=2) and disagreements in incident investigations about the cause (*N*=4), or because there was too little information (*N*=8).

Roughly one in five cases (*N*=101; 21 %) revealed that the perpetrators undertook complex tactical approaches seemingly in order to assure as much carnage as possible. These tactics were used in 27 countries altogether, but mainly in India (*N*=16), Sri Lanka (*N*=15), Algeria (*N*=12), and Iraq (*N*=10). Beginning an attack during rush hour or when a vehicle was at a station were examples of *maximizing population exposed* (*N*=32). Another technique was that of targeting victims with axes, knives, or firearms one-by-one in *execution*-style attacks (*N*=23). In some execution attacks, there was an obvious selection process in which some passengers were selected, while others were released, after showing identification papers or reciting certain prayers to prove kinship or religious affiliation. However, in other cases, whole busloads of passengers had their throats slit or were lined up and shot point blank for no apparent reason, except that they were "in the wrong place at the wrong time" in a context of civil strife or drug war. There were incidents were the perpetrators used several types of attacks in succession, here called the *over-kill* technique (*N*=29). Examples of over-kill were stopping a vehicle with a mine or bomb and following up with shooting at the vehicle or fleeing survivors, or firing at the vehicle first and later setting it on fire. In a few cases, buses were pushed off cliffs or victims thrown off trains at full speed, in combination with other armed attacks. Both the execution and the over-kill techniques required perpetrators to stay on site for a longer time, with over-whelming firepower at hand or numerically superior to the victims. In a few cases, perpetrators took measures so as to *enhance weapon effects* (*N*=11), i.e., make them more effective at doing harm to the victims. Examples of this were seen in incidents where nails or scrap metal were added to bombs, where bombs were detonated in confined spaces such as trains in tunnels or when vehicles were set alight while blocking the exits. Secondary *attacks against rescue personnel* and hospitals (*N*=6) were manifested as a another bomb detonated on site, as the rescue personnel got there—which may be the most obvious danger—but there were also examples of attacks in or outside of the receiving trauma department timed to target survivors, rescue personnel, and worried family members while also taking out critical medical infrastructure as seen, e.g., in the multiple-target attacks in Ahmedabad, India in 2008. Most of these techniques (*N*=90; 89 %) were used during the last two decades and secondary attacks against rescue personnel were exclusive to the 21st century.

Fatally and non-fatally injured

During the 40-year period included in this study, 18,769 people lost their lives in MCAs on public transportation (m=39) and 32,641 were non-fatally injured (m=69). The average number of fatalities fluctuated slightly over the decades (range m=27–48), but the average number of injured in these attacks continuously increased, from an average of 33 to 107 non-fatally injured per incident. Despite the fact that the incidence rate has been quite stable since the 1980s, there was a huge increase in the total number of non-fatally injured people from the incidents during the last two decades (Fig. 3). The 9/11 incidents in 2001 and the Tokyo subway attack in 1995 each had over 6,000 injured and were the major contributors to these huge numbers of non-fatally injured. The 10 incidents that fatally injured the most people accounted for 29 % of the fatalities (*N*=5,379) and the 10 incidents that non-fatally injured the most people accounted for 55 % of the injuries (*N*=18,097), even though they only accounted for two percent of the incidents.

The numbers of fatally (*N*=6,948) and non-fatally injured (*N*=16,532) were highest in Asia, but the high incidence lowered the average fatalities per incident (FPI) (m=29) and injuries per incident (IPI) (m=70) in that region (Table 1). On the contrary, North America had high FPI (m=90[a]) (despite excluding 9/11), because there were so few incidents there severe enough to meet the inclusion criteria. Europe also had high numbers of FPI (m=81) and IPI (m=196); fatalities were mainly due to attacks against the air-bound sector during the 1980s and injuries mainly due to the multiple-target attacks in Madrid 2004 and London 2005.

The air-bound sector had high FPI (m=80) and low IPI (m=8), largely due to the fact that if an incident was severe enough to result in an MCA, it was usually catastrophic. Each flight accommodated many passengers, and the MCAs often

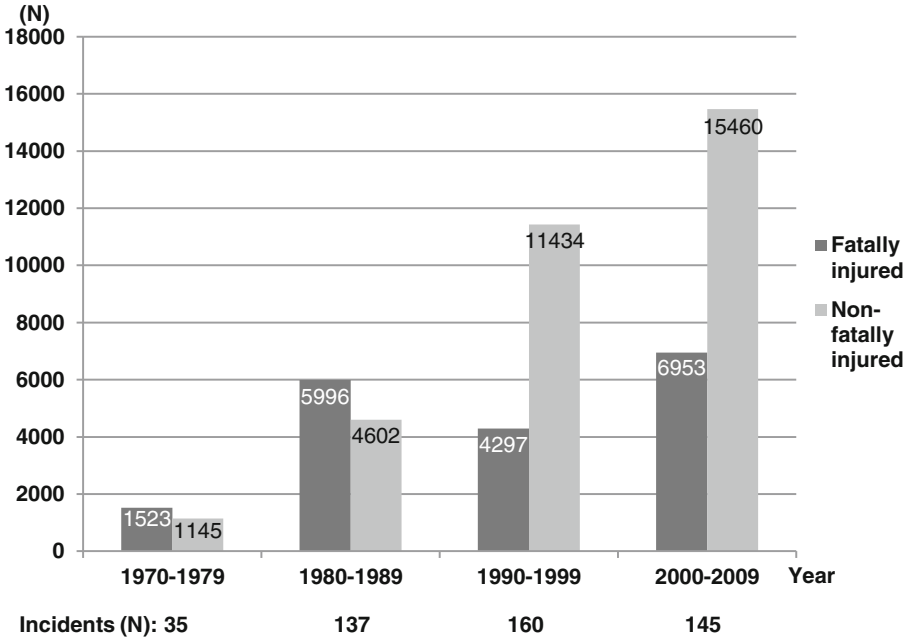

Fig. 3 Fatally and non-fatally injured people in MCAs on public transportation, 1970–2009

Table 1 Fatally-injured, average fatalities per incident (FPI), non-fatally injured, and average injuries per incident (IPI) as distributed in different regions, by transport mode, and dependent on type of attack

	No. of incidents	Fatally injured	FPI	Non-fatally injured	IPI
Region					
Asia	236	6948	29	16532	70
Europe	19	1547	81	3715	196
Latin America	30	674	22	169	6
Middle East & North Africa	104	2469	24	3017	29
North America	4	3264	90[a]	6466	25[a]
			816[b]		1617[b]
Russia & NIS	21	980	47	957	46
Sub-Saharan Africa	63	2887	46	1785	28
Transport mode					
Air	56	4594	82	467	8
Rail	78	3049	39	5435	70
Road	251	4925	20	4719	19
Water	23	992	43	678	29
Terminal	46	1048	23	3881	86
Multiple targets	23	4161	53[a]	17461	503[a]
			181[b]		759[b]
Type of attack					
Armed assault	158	4382	28	9334	59
Arson	8	673	84	250	31
Bombing/Explosion	264	8368	32	15126	58
Hijacking/Hostage Taking	24	4118	49[a]	6936	24[a]
			172[b]		289[b]
Sabotage	9	428	48	946	105
Other/Unknown	14	800	57	49	4

[a] average excluding 9/11 [b] average including 9/11

resulted in the death of all passengers and crew onboard, leaving few non-fatally injured. In contrast, attacks against terminals (IPI=86) and rail (IPI=70) on average led to many non-fatally injured. The attacks against multiple targets resulted both in high FPI (m=53[a]) and IPI (m=503[a]). Out of the ten incidents that contributed most to the high number of non-fatally injured, five were categorized as "multiple-target" attacks, whereas only one of the top ten incidents that led to the most fatalities was multiple target. Thus, attacks against multiple targets have been largely effective at injuring a large number of people; however, single incidents often cause more fatalities (excluding 9/11).

Bombings (FPI=32) and armed attacks (FPI=28) caused the fewest average number of fatally injured per incident, despite being the most common types of attack. Arson was a highly lethal method (FPI=84), while sabotage (IPI=105) on average led to many non-fatally injured. However, both these types of attacks were rare. Of the attacks defined as bombings (*N*=264), 51 were deemed suicide bombings. All but two

of these occurred during the last two decades, with 41 MCAs on public transportation caused by suicide bombings (80 %) occurring since the start of the 21st century. For non-suicide bombings, the average number of people killed was 34, while the average number of people killed from suicide bombings was 22. Conversely, when it came to the number of non-fatally injured, the situation was reversed; in suicide bombings, the average number of injured was 68, while the average number of injured from the other bombings was 55. There were also cases (*N*=13) where the perpetrator(s) died due to the choice of execution of the attack; two cases of arson—one in the confined spaces of a subway and another in an airplane—and several cases (*N*=11) of hijacked vehicles that crashed or were crashed on purpose by the pilot (excluding disputed cases (*N*=4) regarding cause). In the attacks with complex tactical approaches mentioned earlier, the average number of fatalities was slightly higher when they were used (m=38 vs. m=32), while the average number of non-fatally injured was over three times as high (m=90 vs. m=29) in those instances (even with 9/11 and Tokyo excluded).

Discussion

This study investigated 477 MCAs on public transportation during the years 1970–2009. The underlying purpose of studying these types of incidents is to ultimately reduce the consequences of such attacks in the future: to collect data on the size of the issue and its characteristics before honing in on possible injury-preventive and mitigative implications. Such an approach is supported by the statement of injury prevention researcher Carolyn Fowler (2009) who said, "if we fail to monitor activities and trends upstream, we cannot equip ourselves to deal with future consequences downstream." In order to provide directions for future research to reduce the consequences of MCAs on public transportation, this discussion will highlight the current trends of targeted modes of transportation and the circumstances that resulted in the most severe consequences, in terms of fatalities and injuries.

Asia (*N*=236; 50 %) and the Middle East & North Africa (*N*=104; 22 %) were the most commonly targeted regions. The overall geographical patterns in terms of the two most targeted regions coincides with Jenkins and Butterworth's (2010) research on all attacks on road- and rail-bound public transportation, which includes attacks with less severe consequences that thus lay beyond the scope of this study. However, the status of Sub-Saharan Africa as the third most commonly targeted region (*N*=63;13 %) in our current study differed from that one, which ranked it second to last in terms of number of attacks. This is likely due to the high average numbers of fatally and non-fatally injured per attack in Sub-Saharan Africa, as shown by Jenkins and Butterworth (2010). Since the inclusion criteria of this study included 10 fatally and/or 100 non-fatally injured, it is "biased" towards attacks with severe consequences. Thus, relatively more attacks from Sub-Saharan Africa were included precisely because they more often led to severe consequences, in comparison to the other study where more numerous, less severe attacks were included mainly from the other regions.

Airplanes were the most targeted transport mode during the 1970s and were also commonly targeted during the 80s. Despite this, the road-bound transport sector has

been the worst hit practically every year since 1985, accounting for over half of all incidents. Irrespective of the debate regarding airport security measures, the number of MCAs involving airplanes internationally have greatly decreased throughout the last two decades. However, one cannot overlook the fact that when attacks against airplanes have occurred, they were the single most deadly target (even excluding 9/11); most people onboard perish in these attacks. Preventive efforts are thus warranted, but the ways in which security in airports and on airplanes is achieved remain unclear. The balance between privacy and national security (Frimpong 2011; Abeyratne 2010) need to be considered, as do the risks of attack versus costs for security measures (Akhtar et al. 2010). Some would hold that keeping terrorists from planes is not even the job of airport security, but of government agencies and law enforcement (Pico 2007). If that holds true then, from a broader perspective, these agencies need to adhere to fundamental human rights in their pursuit and capture of people suspected of planning or actualizing attacks—or they risk being counterproductive (Hoffman 2004).

An increase in attacks against terminal buildings has been noted during the 21st century. More than half of the incidents occurred after the year 2000 and resulted in many injuries compared to other targeted transport modes. During the last decade, harbors, airports, and stations were the most targeted sector, second only to road-bound transport. In studies of bombings and incendiary attacks against public bus transportation, other researchers (Jenkins et al. 2010) have also found that the percentage of attacks directed at bus stations and bus stops have increased significantly, while attacks on buses have decreased. The increase in incidence and severe consequences, in terms of injuries, from these attacks indicates a need to focus preventive efforts especially around terminals. In the UK, their experiences of attacks perpetrated by the Irish Republican Army (IRA) as well as other incidents led to the introduction of design and technological strategies of the Crime Prevention Through Environmental Design (CPTED) program (Jenkins and Gersten 2001). Taylor et al. (2005) proposed several reasons why such design changes have not been given much attention in the literature of transit terrorism security. For one, some now perceive security to be an illusion in an era of suicide bombings and that there is no defense against a determined terrorist. Thus, the best hope for transit is to minimize disruption by having an organized response strategy. The researchers go on to point out that such a fatalistic mindset ignores the potential role that design plays in security planning against individual crimes and terrorism. Design constitutes one of many layers of protective strategies. Even if good policing is the best defense and effective response is the best way to minimize the effects of an attack, design can serve as an important function. The goal of CPTED is to influence the social and physical use of space through environmental designs that discourage antisocial and criminal behavior (Taylor et al. 2005). Design strategies also include opportunities for dual-use to improve safety and efficiency within the public transport system as well as innovative construction and material use, all of which can reduce the risk of injury if an attack does occur. In relation to the rail-bound sector, O'Neill et al. (2012) have suggested that counter-measures such as the choice of materials and design can mitigate the effects of attacks making a target less attractive for terrorists and reducing the risk of future attacks. In addition to structural designs to mitigate the

effects of an attack, they also propose design upgrades to key systems that would improve survivability by enabling efficient management of rescue operations.

Attacks with multiple targets, as part of a coordinated assault on public transportation, have been quite few in number but have led to severe consequences when they occurred. The most telling examples of this were the 9/11 attacks and the Tokyo subway attacks, which had major impact on the numbers of injured during the last two decades. The five incidents leading to the most numerous non-fatally injured were all incidents with multiple targets. Moreover, the 10 incidents that caused the most fatalities and the 10 incidents that caused the most non-fatally injured accounted for 29 % of fatalities (N=5,379) and 55 % of non-fatal injuries (N=18,097), even though they only accounted for 2 % of the incidents. This shows what an immense impact a few incidents can have in terms of consequences. By extension, it implies that while some regions have been targeted more often than others, the consequences of attacks in terms of fatally and non-fatally injured people may not coincide. As pointed out by Gary LaFree (2012) the perception one may get from the media coverage – that no location is safe from terrorism – is a myth. He however also cautioned against ignoring the threat, due to its unpredictable and bursty nature. Thus every society should be prepared to deal with such an incident, in order to minimize its consequences.

Bombings and armed assault were by far the most common types of attack, accounting for nearly 90 % of the MCAs on public transportation. Consequently, these were connected to the highest absolute numbers of fatally and non-fatally injured people. Since bombings constitute the primary attack type, many of the incidents result in blast injuries, which civilian medical communities may be ill-prepared to handle (Frykberg 2002). Unsurprisingly, medical responses to attacks are often more sophisticated and effective in countries that are more commonly exposed (Frykberg 2002). Israel is one example where experiences of attacks have prompted advances in medical management and the development of "terror medicine" as a discipline (Shapira and Cole 2006). Military medical forces constitute another resource from which the civilian medical community can learn, as they are well prepared and trained to deal with mass casualty incidents with similar injury spectrum (Frykberg 2002).

Despite gaps in knowledge and resources for some areas of the world, this study also showed that the average number of fatalities per incident was lower for bomb attacks and armed assaults than other attack types. Arson was a more deadly attack type, while sabotage caused many non-fatally injured. The development and spread of the suicide bombing technique have caused considerable concern and fear for officials and populations of countries that have been attacked by or are likely targets of such attacks (Jenkins and Butterworth 2010). In this study, 51 MCAs were considered caused by suicide bombings, i.e., roughly 10 % of the total. Moreover, practically all of these incidents occurred during the last two decades. The data also indicated that they caused slightly more non-fatal injuries than other bombings and that those bombings using timers, remote controlled devises, or pressure triggers were seemingly more deadly. This coincides with Jenkins and Butterworth's (2010) findings that suicide bombings are generally not the most lethal combination of attack and weapon and that most terrorist campaigns deliver bombs in other ways because it is far easier.

The development of complex tactical approaches to increase the number and severity of injuries among victims is disconcerting; almost 9 out of 10 (N=90;

89 %) of such attacks have occurred since 1990. These techniques generally only increased fatalities slightly (m=38 vs. m=32) but led to more than a threefold increase of average number of non-fatally injured (m=90 vs. m=29). Examples of this were *maximizing exposed population* (beginning an armed attack when as many people as possible will be exposed, e.g., when a train is in station; *N*=32), by *enhancing weapon effects* (e.g., adding nails in bombs or detonating in confined spaces; *N*=11), by approaching the victims one-by-one *execution* style (*N*=23), by using an *over-kill* technique (combining several types of attack; *N*=29), or through secondary deliberate *targeting of rescue personnel* or hospitals (*N*=6). These tactics were most commonly used in India (*N*=16), Sri Lanka (*N*=15), and Algeria (*N*=12), the same three countries with the highest incidence of MCAs against public transportation.

Clearly a lot has happened in the arena of antagonistic attacks in the last 40 years. Terrorism expert Brian Jenkins has gone from saying that "terrorists want a lot of people watching, not a lot of people dead" (Jenkins 1985) to giving testimony that "terrorists who target transportation systems are often seeking slaughter" (Jenkins 2004), approximately 20 years later. With regards to public surface transportation, Jenkins and Gersten (2001) pointed out that people with malicious intent now perceive these areas as "killing fields" and that they cannot be stopped altogether. Nevertheless, fatalism is not an appropriate response since, e.g., explosive devices can indeed be found and defused and passengers can be evacuated before an explosion (Jenkins et al. 2010).

Attacks on airplanes have caused the highest average number of fatalities, but to prevent these fatalities the incidents themselves must likely be prevented altogether. In terms of non-fatal injuries from MCAs on public transportation, which have increased during the last two decades, attacks against terminal buildings, multiple targets, and attacks carried out with complex tactical approaches have been major contributing factors. Attacks involving several incident sites require more coordination, and those with large numbers of injuries constitute challenges for, e.g., triage, logistics, medical resources, and knowledge, while also keeping security issues in mind. Such incidents constitute the ultimate test for the societal response system in a country, and may very well require outside assistance. In-depth studies of the past can provide valuable knowledge for the future for the development of emergency preparedness within organizations that would be on site after an attack—the first responders.

Methodological considerations

The major strength of this study was the comprehensiveness of the data collection, which included antagonistic acts and not just the terrorism cases found in the Global Terrorism Database. By searching outside of the GTD, 96 additional cases were found. As described by LaFree and Dugan (2007), databases like the GTD rely on reports about terrorism from print or electronic media, which involves some limitations, one of them being an inherent bias towards the most newsworthy forms of terrorism. This could have influenced the data in this study, especially in regions with less media penetration or possibly where such antagonistic acts have become so common that the public's interest in the issue has been "saturated". Moreover, government censorship and disinformation could also affect results. Authorities

may be reluctant to disclose certain information for fear of looking weak, or unwilling to admit to any terrorism in its territory. On the other hand, governments may also use attacks and inflate the number of casualties as a justification for more repressive tactics. The targeted state or terrorist organization may both have reasons to inflate or deflate certain numbers or threats as part of their strategy to affect the credibility of their opponent and disorient the public (Neumann and Smith 2005). Despite searching for additional data from open media sources, reports, scientific journals, and books, these issues remain, which implies that the study is still not all-encompassing.

An associated strength of the additional data search was the validation of information from the database. Only through merging the GTD data and the additional data and then re-searching the GTD could 52 more cases be found. This was because those cases had not been classified in any of the "aviation," "maritime," or "transportation" categories or because the numbers were not updated, so they initially fell below the cut-off point in the GTD. The counts presented should still be considered estimates, rather than exact—an innate weakness of the research. Identifying the number of persons killed in any given attack is extremely difficult because, prior to an attack, it is generally unknown how many people are onboard a particular mode of transport (with the exception of airliners). For example, with respect to sea-bound modes of transport, it is intrinsically difficult to determine the number of victims since some may be lost in the water. Jenkins and Butterworth (2010) also mention difficulties regarding count, e.g., stating that reports on fatalities generally are more accurate than reports on injuries. Furthermore, some countries may record only serious injuries, which can be defined differently, while others report all injuries. Finally, some injuries later become deaths, and these may not be updated in media reports.

Conclusion

Increased numbers of non-fatally injured people from contemporary mass-casualty attacks on public transportation were connected to attacks on terminal buildings, multiple targets and complex tactical approaches. Therefore, future in-depth research of such incidents is required in order to develop more effective emergency preparedness among first responders, with regard to the specific challenges when dealing with the consequences in the immediate aftermath of an attack.

Acknowledgments The authors thank the Swedish National Board of Health and Welfare for financial support. Critical readings of the manuscript by Professor Britt-Inger Saveman were also appreciated.

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